NOTE ON PILOTS' OBSERVATIONS OF AIR CURRENTS IN AND NEAR THUNDERSTORMS

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About 10 o'clock on the evening of September 10, 1928, an air-mail pilot took off from Moline Airport for Kansas City. Weather conditions were very much unsettled and thunderstorms were indicated over the route he was to follow. He found, however, that there was a ceiling of about 1,000 feet, fairly good visibility and very little rain, and he experienced no trouble until he was about 15 miles beyond Fairfield, Iowa. There he found that he was nearing a thunderstorm of considerable dimensions and decided to circumvent it, if possible. The storm was moving from the southwest and he elected to run along the northeastern edge, or forefront, of it, rather than to go so far out of his way by skirting the northern edge.

After following the new course for about 5 miles, he decided to start using gasoline from the other wing tank, and so leaned down in the cockpit to turn it on. While in that position the ship was suddenly thrown almost entirely over on its back and the altimeter showed 3,500 feet within about 20 seconds, according to the pilot's estimation. After righting the ship, the pilot returned to Moline Airport, judging that the storm he was near was of particular violence aloft and it would be foolhardy to continue. He stated that, since it was very dark, he could not tell whether the high altimeter reading was due to being lifted upward very rapidly or to suddenly lowered pressure of the atmosphere.

The turning over of the plane can be accounted for, as it is well known that there are rapidly ascending and descending currents in a thunderstorm. It is also known that the barometric pressure decreases sharply in the forefront of a thunderstorm and then increases rapidly as the storm passes over a given point, but if this sudden change of 2,500 feet (he was flying at about 1,000 feet) shown by the altimeter was due to a sharp lowering of pressure, the decrease would amount to not less than 65 millimeters, which is manifestly rather improbable, except in the presence of tornadic conditions. Such conditions were very probable at that time when the distribution of several of the meteorological elements are taken into consideration. The 7 a. m. weather map for September 10, 1928, shows a long trough of low pressure stretching northeastward across the Plains States and that thunderstorms had already occurred over the western portions of this area. There is also a sharp variation of temperature shown from HIGH to LOW from east to west. These evidences, combined with the pilot's account that it occurred in the forefront of a thunderstorm, with no rain occurring before, seem to point to the probability of the presence of tornadic conditions.

On the other hand, if the altimeter change was due to an uprising current of air, the velocity of the current would have been approximately 38 meters per second; this seems rather high, although it corresponds very well with statements made by various pilots concerning the velocity of these currents and their effects upon an airplane.

Pilots who have been asked concerning experiences along this line are generally of the opinion that a violent uprising current of air in the front of the storm tossed the plane about and also lifted it very rapidly. Several stated that they have flown directly through thunderstorms and at the front of the storm have been struck by squalls which were made up of descending currents so violent that their utmost efforts were required to keep the ship from crashing, and after passing the front were lifted by the ascending currents into the clouds and could hardly get the plane down, even by pointing downward with the engine on.

The foregoing seems to indicate that in some thunderstorms the vertical air currents are much more violent than is generally supposed. Another inference would be that tornadic conditions may form aloft, of which no indication is perceived at the surface.

FIVE YEARS OF OCEAN MAPPING AND ITS FORECAST VALUE

By L. E. BLOCHMAN

[Berkeley, Calif.]

INTRODUCTION

Long-range, or seasonal, forecasting has so far been only cursorily investigated, particularly on the Pacific coast. Both short-range and long-range forecasting have been immensely assisted by ocean charting from daily radioed weather reports from ships. The main application of this service, however, is to daily or short-range forecasting; long-range forecasting is still in a tentative state for lack of sufficient data.

The ocean mapping system was not established without considerable difficulty. Credit is due to the San Francisco Weather Bureau service for its persistence in obtaining a sufficient number of ship reports to cover the desired ocean area. This extends from Honolulu to the westerly Aleutian Islands, and from this approximate westerly line to the Pacific coast of Canada and the United States on the east. The land stations of Guam, Manila, Hong Kong, St. Pauls Island in Bering Sea also report to the bureau.

As a layman I am studying prevalent seasonal conditions, especially the ocean movements of HIGHS and LOWS, with their concomitant rains; the result of these studies is but partially embodied in this paper. In this article I also briefly discuss the recent ocean-mapped seasons, especially the very dry season of 1923–24 and the more than average rainy one of 1926–27, and some casual weather conditions of two other seasons.

THE SEMIPERMANENT LOWS AND HIGHS

In scanning our ocean and land maps for any series of years we find two dominant centers of pressure, the so-called semipermanent Aleutian LOW and the semipermanent HIGH which lies off the California coast about 15° to the west. The center of the Aleutian LOW is immediately south of the islands of the same name, but its center may vary for a thousand miles east or west.[1] The center of the semipermanent HIGH, above referred to,

[1] This apparent variation is explained by the fact that the so-called Aleutian cyclone owes its semipermanent character to the giving off of secondary depressions on its eastern front and receiving accessions from the west every few days. As a result the center of the cyclone seems to be stationary for a few days and then suddenly to change its position 500 to 1,000 miles to the westward.—*Editor.*

is not so definitely located as to latitude, ranging often between 30° and 40°. Sometimes the HIGH in winter stretches across easterly by northeasterly to the plateau between the Sierras and the Rockies. When there is a persistent dry spell in winter a plateau HIGH may exist at the same time.

This semipermanent HIGH, known as the California or the Hawaiian HIGH, dominates our coast. It is a little farther north in summer than in winter and much more permanent in summer and in very dry winter seasons than in rainier seasons. Its major axis is subject to change in summer or in the dry spells of any winter. When temporarily displaced it has an inherent tendency to return to its more or less permanent position lying east and west approximately between longitude 130° and 150° and latitude [2] 30° and 40°.

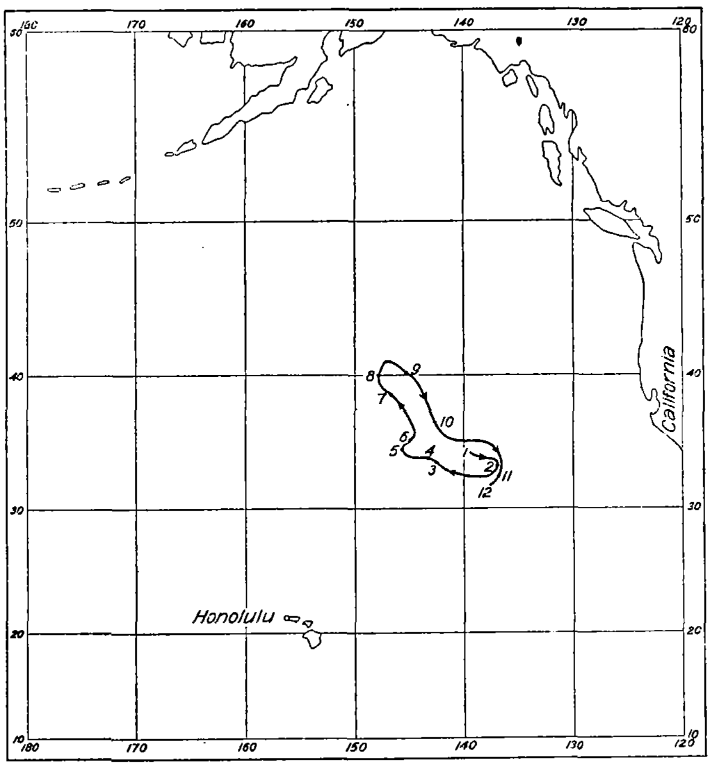

FIG. 1.—Seasonal meander of North Pacific anticyclone. The numerals 1–12 stand for the months January-December, inclusive

It is a part of the high-pressure belt which encircles the globe about north latitude 35°. Over the two oceans it is at its highest pressure west of their respective continents. The effect of this pressure distribution is to cause a marked shortage of rainfall along its southern side, as manifest in the Sahara and other deserts.

On the Japanese coast and on the Atlantic side of the United States the belt of high pressure is more or less broken up by cyclonic storms and is not therefore continuous at all times. Off the California coast this semipermanent high pressure in very dry winters seems almost as intense and persistent as in summer seasons.[3]

According to my observations when the summer HIGHS of September continue into October and still further into November, with concomitant plateau HIGHS, we have the probability of a below-average rainy season. The higher the pressure as the rainy season moves on to the latter half of November and into December, the greater the probability of a dry season and not of a mere dry spell. When there is more or less mobility of pressure, i. e., occasional fluctuations to lower pressure, we may construe conditions as a later opening winter season.

With land maps only to forecast from this is a very uncertain problem because some of the conditions are unknown. It can be readily seen that ocean mapping helps immensely by giving us the lacking data. I shall endeavor to illustrate this as I proceed. There are still elements of uncertainty in long-range forecasting that only further investigations will minimize. Ocean mapping and particularly the resultant effect on our scientific theories are still in their infancy.

COMPARISON OF SEASONS

There are marked contrasts in even these last five seasons and we shall first compare two of them of opposite trend, the dry season of 1923–24,[4] and the above average rainy season of 1926–27.[5] In looking at the ocean weather maps for October and November, 1923, they seemed to be a continuation of the average summer HIGH, and the rains were very light, mere tapering rains from the north. But in October, 1926, several cyclonic or low-pressure areas moved south to almost latitude 30°, the southern limit of the summer HIGH and so displaced it completely. It did not yet rain appreciably in the State, the LOW center moving too far to the northeast as it passed inland, but it was a true forecast for rains in the following month. On November 17, 1926, the weather map showed a deep LOW of 29.40 inches opposite Point Conception with its center along the one-hundredth and forty-fifth meridian of longitude. But over the plateau the land map showed the excessive high pressure of 30.50 inches, due to some cold land conditions. Certainly no one, a short or a long-range forecaster, could have predicted any rains from the land map, but the ocean map justified a forecast of a very heavy rain; indeed, 6 inches fell at San Francisco, and 7 at San Luis Obispo (near Point Conception) within the following 10 days. These were excessive rains for November.[6]

The interior always has higher pressure in winter than in summer, the opposite of normal ocean conditions. The only difference observed as regards seasons is that the average pressure is higher and semipermanent in drier seasons, but in normal to wet seasons the higher and lower pressures fluctuate and alternate quite frequently.

The problem of long-range forecasting even from ocean charts is not so simple in ordinary seasons as in extreme ones. For instance, high oceanic pressure in October and November and even in December may be due in part to a later opening season, a belated summer condition, or to some other cause. The season of 1925–26 had very light rains until January; in fact, in the bay region December was much drier than November. In forecasting at the time I observed that this would not be a dry season, as Los Angeles and southern points had

[1] The marine division of the Weather Bureau made for the editor some time ago a drawings showing the average annual migration of the North Pacific semipermanent anticyclone. The drawing is produced as Figure 1 of this article.—*Editor*.

[2] Cf. A. J. Henry in the Winter Anticyclone of the Great Basin, this Rev. *56:* pp. 125–128.

[4] Typical weather chart of dry season 1923–24, February 26, 1924. Deep low, 28.1 inches centered over Bering Sea and the west coast of Alaska. North Pacific anticylcone in normal position. Pressure over interior of continent unknown.

[5] Typical weather chart for wet season of 1926–27, November 17, 1926. Circular low centered in West longitude 145°, North latitude 35°. Pressure high over Bering Sea and the interior of continent west of one hundred and tenth meridian—a typical pressure distribution for rains in southern California.

[6] Typical weather chart, October 13 and 22, 1926, for heavy rains in November. Both show a deep depression in the neighborhood of Dutch Harbor with the outer limit extending southeast nearly to California coast. North Pacific anticyclone absent and pressure over continent not unusually high.

received about three times the rainfall of the bay region. Lows had moved directly south which, like October, 1926, indicated favorable future rains. Copious January, February, and April rains brought the season up to a full normal one. Of belated opening rainy seasons we may incidentally refer to 1910–11, when only 2¼ inches of rain fell in Sacramento from September through to the end of December. In January following torrential rains came to the Sacramento Valley causing serious floods; Sacramento city had 12¾ inches, Nevada City (the same valley at the 2,500-foot elevation) had 36 inches. Had we had ocean mapping at that time, undoubtedly pressure movements in December would have indicated as it did in October, 1926, future heavy rains.

The season of 1924–25 of this ocean-mapped group shows a dry condition in the south, but full average from Salinas-Fresno northward. There are several such seasons of dry conditions in the south and normal rainfall northward. The weather map for December 30, 1924 (a dry period for southern California), shows the HIGH off the California coast with deep LOW northward, over the Gulf of Alaska. But the subsequent LOWS moved much farther south than in the previous dry season, and the HIGHS were not so persistent.

LOW-PRESSURE MOVEMENTS

The main low-pressure or cyclonic movement, known as the Aleutian LOW, has been carefully and continuously studied and does not need any attention in this discussion. There are, however two other low-pressure movements related to the northern low-pressure system, the Hawaiian LOW and the intermountain LOW, or the so-called Alberta or Alberta-Plateau LOW.

ALBERTA LOWS [7]

The Alberta LOW has been really misnamed; it should have been called the intermountain LOW. It is a LOW that has moved inland along the southern Canadian line and become deflected southerly about the Province of Alberta and often before it has reached that Province. It is a cyclonic formation between two HIGHS, deflected as it encounters the easterly HIGH. In moving south toward southern Nevada and southeastern California it comes under the influence of the Pacific Ocean and its cyclonic life is revivified, and precipitation follows for central and southern California, often quite heavy.

In the dry season of 1923–24 the persistent HIGH of this coast seemed as immovable as in summer. There was no probability in spring of any LOW being deflected down the California coast with such an anticyclonic condition. But in three different periods in March this Alberta cyclonic movement gave the parched south above-average rains foi the month: San Diego, 2½ inches; Los Angeles and Santa Barbara, 3½ inches; and San Bernardino, 4½ inches. April also had two similar rains, though lighter in amount. Los Angeles received about 1½ inches, San Bernardino and Redlands a full 2½ inches, while its influence, barely felt around the bay, gave San Francisco only 0.30 inch.

We give so much attention to this type of LOW because we have never seen any reference paid to this particular source of rain for southern California. It is particularly a factor to be reckoned with in rains from March on. The applicability is shown in the following forecasts made in April, 1927, and this last April. About the middle of April, 1927, I forecast in a local paper (*The Berkeley Gazette*) that the rainy season was over, due to the tapering off of the northerly coast rains and particularly to the persistent oceanic high pressure. This was a correct forecast. About the same time this year under the same conditions I was correct only as far as the upper coast rains were concerned. An unexpected Alberta LOW developed during the second week of May which gave southern points from Bakersfield south ½ to 1¾ inches of rain, tapering off in the bay district to 0.30 inch.

THE HAWAIIAN LOW [8]

The Hawaiian LOW is so called because first observed in the vicinity of these islands. It most likely is a southerly deflection of the Japanese-Alaskan low-pressure system before it reaches its usual center. Sometimes rainstorms are light, sometimes very heavy, from this source; they are warmer in temperature than the Alaskan LOW because traversing a warmer belt.

Whenever an Aleutian LOW moves south and a Hawaiian LOW exists west of the California coast at the time, they apparently intensify the precipitational effect of each other. Such a coincidence was in evidence in February, 1927, which accounted for some tremendous rains in southern California in a short period of time. It can be traced in the weather maps of February 12 and 13.

On March 22 and 23 of this year it was raining in the Sacramento Valley and snowing in the mountains. On the 23d and 24th a Hawaiian LOW moved in and augmented the precipitation and the warmer Hawaiian LOW apparently melted the mountain snows causing heavy floods in the valley.

This brief and rambling discussion about a few recent seasons and about high and low oceanic pressures is only a partial proof of the value of ocean mapping for long-range forecasts. For short-range it is too self-evidently necessary to need any comment.

My accumulated data of years on various climatic factors bearing on long-range forecasting would have been of more value if we had had concomitant ocean maps previous to 1923.

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[7] The Weather Bureau classification of LOWS, as has been frequently stated, is based solely upon the place where the LOW is first charted on the daily weather maps. It is held that Alberta LOWS are of Pacific origin, but the evidence as to the precise path followed previous to their appearance in Alberta is not yet conclusive.—*Editor.*

[8] Undoubtedly the author has in mind a cyclonic depression that occasionally is found as far south as Honolulu. Meteorologists do not recognize a distinctive LOW that could be called the "Hawaiian" LOW.—Editor.

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